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# SUMMARIES OF CURRENT NORTH AMERICAN PRE-CAMBRIAN LITERATURE[1]

CLEMENTS, SMYTH, BAILEY, and VAN HISE[2] describe the Crystal Falls iron-bearing district of Michigan.

The rocks of the district comprise two groups, separated by unconformities. These are the Archean and the Algonkian. The Algonkian includes both the Lower Huronian and the Upper Huronian series, and these are also separated by unconformities. The terms Lower Huronian and Upper Huronian are applied to the series which occur in this district because they are believed to belong to the same geological province as the Huronian rocks of the north shore of Lake Huron, and to be equivalent to the Lower Huronian and Upper Huronian series which there occur.

The Archean is believed to be wholly an igneous group, and therefore no estimate of its thickness can be given. It covers a broad area in the eastern part of the district, and from this several arms project west. West of the main area there are two large oval areas of Archean.

The Lower Huronian series, from the base upward, comprises the Sturgeon quartzite, from 100 feet to more than 1000 feet thick; the Randville dolomite, from 500 to 1500 feet thick; the Mansfield slate, from 100 to 1900 feet thick; the Hemlock volcanic formation, from 1000 to 10,000 or more feet thick; and the Groveland formation, about 500 feet thick. A minimum thickness for the series is about 2200 feet, and a possible maximum thickness is more than 16,000 feet. However, in the latter case, a large part of the series is composed of volcanic material. It is not likely that the sediments at any one place are as much as 5000 feet thick.

The Upper Huronian is a great slate and schist series, which it is not possible to separate on the maps into individual formations. It is impossible to give even an approximate estimate of the thickness of this series.

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[1] Continued from page 443, Vol. VIII, JOUR. GEOL.

[2] The Crystal Falls Iron-bearing District of Michigan, by J. MORGAN CLEMENTS and H. L. SMYTH, with a chapter on the Sturgeon River Tongue, by W. S. BAYLEY, and an Introduction by C. R. VAN HISE: Mon. U. S. Geol. Surv., No. XXXVI, 1899. With geological maps.

Various igneous rocks intrude in an intricate manner both are Upper Huronian and the Lower Huronian series.

In the following paragraphs the descriptions of the formations we summarized somewhat more in detail.

*The Archean.*— The Archean consists mainly of massive and schistose granites and of gneisses. Nowhere in the Archean have any rocks of sedimentary origin been discovered. The Archean has been cut by various igneous rocks, both basic and acid, at different epochs. These occur in the form both of bosses and of dikes, the latter sometimes cutting, but more ordinarily showing a parallelism to, the foliation of the schistose granites. The granites must have formed far below the surface, and therefore must have been deeply denuded before the transgression of the Lower Huronian sea. The Archean granites and gneisses and the earlier intrusives alike have been profoundly metamorphosed, and at various places have been completely recrystallized.

*The Lower Huronian series.*—The Sturgeon quartzite, the first deposit of the advancing sea, when formed consisted mainly of sandstone, but in places at the base it consisted of coarse conglomerate. The conglomerate is best seen in the Sturgeon River tongue. Elsewhere evidence of conglomeratic character at the base of the formation is seen, but the metamorphism has been so great as nearly to destroy the pebbles. However, in the Sturgeon River tongue is a great schistose conglomerate, which, while profoundly metamorphosed, still gives evidence of the derivation of its material from the older Archean rocks. The sandstone has been changed to a vitreous, largely recrystallized quartzite, which now shows only here and there vague evidence of its clastic character.

The Sturgeon formation varies from probably more than 1000 feet in thickness in the Sturgeon River tongue to less than 100 feet in thickness at places in the Felch Mountain range, and is altogether absent in the northeastern part of the district.

In the southeastern part of the district the Sturgeon quartzite is overlain by the Randville dolomite. In the central part of the district the quartzite between the Archean and the Randville is so thin that it cannot be represented on the maps as a separate formation. In the northeastern part of the district a quartzite, resting on the Archean, but occupying a higher position stratigraphically than the Randville dolomite, is overlain by an iron-bearing formation. It appears, therefore, that the Sturgeon sea gradually overrode the district, and that at the time the Sturgeon quartzite was deposited in the southeastern part of the area the Archean was not yet submerged in the central and northeastern parts of the district. However, since the quartzite resting on the Archean in the latter area cannot be separated lithologically from the Sturgeon quartzite, both are given the same formation color, but the later quartzite is given a separate letter symbol. The quartzite color therefore represents the transgression deposit of the same general lithological character, rather than a formation all parts of which have exactly the same age. While nowhere in the district is there any marked discordance between the schistosity of the Archean and the Sturgeon quartzite, the conglomerates at the base of the latter formation in the Sturgeon River tongue are believed to indicate a great unconformity between the Archean and the Lower Huronian series. The change from the Sturgeon deposits to those of the Randville was a transition.

The Randville dolomite is a nonclastic sediment, and is believed to mark a period of subsidence and transgression of the sea to the northeast, resulting in deeper water for much of the district. Since the Randville dolomite has its full thickness on the Fence River just east of the western Archean oval, and does not appear at all about the Archean oval a short distance to the northeast, it is probable that the shore line, during Randville time, was between these two areas and that the land arose somewhat abruptly toward the northeast. As the Randville formation has a thickness of 1500 feet, it probably represents a considerable part of Lower Huronian time.

Following the deposition of the Randville dolomite, deposits of very different character occur in different parts of the district. These deposits are: (1) The Mansfield formation, (2) the Hemlock volcanic formation, and (3) the Groveland formation.

The Mansfield formation was a mudstone, which has subsequently been transformed into a slate or schist. The Hemlock formation is mainly a great volcanic mass, including both basic and acid rocks, lavas, and tuffs, but it contains also subordinate interbedded sedimentary rocks. This formation occupies a larger area than other of Lower Huronian formation, and is perhaps the most characteristic features of the Crystal Falls district. The Groveland is the iron-bearing formation. It includes sideritic rocks, cherts, jaspilites, iron ores, and other varieties characteristic of the iron-bearing formations of the Lake Superior region. In all important respects these rocks are similar to those of the Negaunee formation of the Marquette district, with the exception that in the southeastern part of the Crystal Falls district, associated with the nonclastic material, there is a considerable proportion of clastic deposits. The Groveland formation contains iron carbonate and possibly glauconite, from which its other characteristic rocks were derived.

The variability in the character of the deposits overlying the Randville formation is probably caused by the great volcanic outbreaks in the western part of the district. In the southern and southeastern parts of the area the deposit overlying the Randville formation is the Mansfield slate and schist. North of Michigamme Mountain and of the Mansfield area the Mansfield formation is replaced along the strike by the Hemlock volcanic formation, which directly overlies the limestone for most of the way about the western Archean oval. The effect of the volcanic outbreak apparently did not reach so far as the northeastern part of the district.

Overlying the Mansfield formation in the southeastern part of the district and the Randville formation in the central part of the district is the Groveland iron-bearing formation. In the Mansfield slate area the iron-bearing rocks appear near the top of the Mansfield formation intercalated with the slates. The Groveland formation cannot be certainly traced farther north than the northeastern portion of the western Archean oval. It is apparently replaced along the strike by the Hemlock volcanics.

In the northeastern part of the district the Groveland formation, equivalent to the Negaunee formation of the Marquette district of Michigan, is found above the Ajibik formation. The occupation, in the western part of the district, by the Hemlock volcanics of the same part of the geological column as occupied by the Hemlock volcanics east of the western Archean oval, the Mansfield slate, and the Groveland formation, is explained by the fact that in the western part of the district the volcanoes broke out and there continued their activity longest. While north of Crystal Falls the volcanic rocks were laid down, the Mansfield formation was being deposited in the southeastern part of the district. This activity continued there through the time in which the Groveland formation was being deposited in other parts of the district.

From the foregoing it appears that the Hemlock formation in the western part of the district is equivalent:

1. East of the western Archean oval, to the Hemlock volcanics found there and the overlying Groveland formation.

2. At Michigamme Mountain, to the Mansfield slates and the Groveland formation.

3. In the Mansfield area, to the Mansfield slates and the Hemlock volcanics occurring there.

4. In the southeastern part of the district, to the Mansfield and Groveland formations.

The replacement of an iron-bearing formation by the great volcanic formation just described is exactly paralleled in the Upper Huronian rocks of the Penokee iron-bearing series, where the pure iron-bearing formation is replaced at the east end of the district by a great volume of volcanic rocks intercalated with slates and containing bunches of iron-formation material.

Following the deposition of the Lower Huronian series, the region was raised above the sea and eroded to different depths in different places. In the Felch Mountain range the only formations above the Randville dolomite are a thin bed of slate and the Groveland iron formation. In the northeastern part of the district only a thin belt of iron-formation rocks remains. In the central and western parts of the district there is a great thickness of volcanics. This, however, does not imply a difference of erosion equal to the difference in thickness of these rocks, for doubtless when the volcanics were built up there was contemporaneous subsidence, so that at the end of Lower Huronian time there may have been little variation in the elevation of the upper surface of the series, but very great differences in its thickness.

*The Upper Huronian.*— After the Lower Huronian series was deposited the district was raised above the sea, may have been greatly folded, and was eroded to different depths in different parts of the district.

Following the earth movements and erosion, the waters for some reason advanced over the district, and the Upper Huronian series was deposited. The basal horizon was a conglomerate, which has, however, very different characters in different parts of the district.

In the eastern half were Archean rocks, the Sturgeon quartzite, the Mansfield slate, and the Groveland iron formation. Upon these was deposited a sandstone which locally was very ferruginous. This has subsequently been changed into a ferruginous quartzite. The typical occurrence of this quartzite is at the end of the Felch Mountain range. It also appears between the Archean ovals in the northeastern part of the district. If distinct conglomerates were formed at the bottom of this quartzite, they are buried under glacial deposits or have disappeared as the result of metamorphism.

In the western part of the district the rocks of the Lower Huronian at the surface are the great Hemlock formation, and here the basal horizon of the Upper Huronian is a slate or slaty conglomerate, the fragments of which are derived mainly from the underlying Hemlock formation. The sandstones and conglomerates varied upward into shales and grits, which have been subsequently altered into mica-slates and mica schists. After a considerable thickness of mudstone and grit was deposited, there followed a layer of combined clastic and non-clastic sediments, the latter-including iron-bearing carbonates. These appear to be at a somewhat persistent horizon, and in this belt are found the iron-formation rocks, and iron ores in the Upper Huronian in the vicinity of Crystal Falls. Above these ferruginous rocks there was deposited a great thickness of shales and grits which have been transformed into mica-slates and mica-schists.

Since the deposition of the Upper Huronian the rocks of the district have been folded. The more complex folds vary from a north-south to an east-west direction. The closer folds in the northeastern part of the area are nearly north-south. In the central part of the area the closer folds strike northwest-southeast. In the eastern and southeastern parts of the district the closer folds are nearly east-west. All of these folds have steep pitches.

Subsequent to, or during the late stage of, this time of folding there was a period of great igneous activity, probably contemporaneous with the Keweenawan. At this time there were introduced into both the Lower and Upper Huronian vast bosses and numerous dikes. The intrusives vary from those of an ultrabasic character, such as peridotites, through those of a basic character, such as gabbros and dolorites, to those of an acid character, such as granites. These intrusives, while altered metasomatically, do not show marked evidence of dynamic metamorphism; therefore the conclusion that they were introduced later than the period of intense folding already described.

Cambrian rocks overlie unconformably the rocks above described.

DESCENDING SUCCESSION OF FORMATIONS IN THE MARQUETTE, CRYSTAL FALLS, AND MENOMINEE DISTRICTS.

| MARQUETTE DISTRICT | CRYSTAL FALLS DISTRICT | MENOMINEE DISTRICT |
|---|---|---|
| UPPER MARQUETTE | UPPER HURONIAN | UPPER MENOMINEE |
| 1. Michigamme formation, bearing a short distance above its base an iron-bearing horizon, and being replaced in much of the district by the Clarksburg volcanic formation. | 1. Michigamme formation, bearing a short distance above its base an iron-bearing horizon. | 1. Great Slate formation. |
| 2. Ishpeming formation, being composed of the Goodrich quartzite in the eastern part of the district, and of the Goodrich quartzite and the Bijiki schists in the western part of the district. | 2. Quartzite in eastern part of the district. | |
| Unconformity | Unconformity | Unconformity |
| LOWER MARQUETTE | LOWER HURONIAN | LOWER MENOMINEE |
| 1. Negaunee iron formation, 1000 to 1500 feet. | 1. The Groveland formation, about 500 feet thick. | 1. Vulcan iron formation containing slates. |
| 2. Siamo slate, in places including interstratified amygdaloids, 200 to 625 feet thick. | 2. Hemlock volcanic formation, 1000 to 10,000 feet thick.<br>In western part of district also occupies place of (1) and (3). | 2. Antoine dolomite. |
| 3. Ajibik quartzite, 700 to 900 feet. | 3. Mansfield formation, 100 to 1900 feet thick. | |
| 4. Wewe slate, 550 to 1050 feet. | | |
| 5. Kona dolomite, 550 to 1375 feet. | 4. Randville dolomite, 500 to 1500 feet thick. | |
| 6. Mesnard quartzite, 100 to 670 feet. | 5. Sturgeon quartzite, 100 to 1000 feet thick. | 3. Sturgeon quartzite. |
| Unconformity | Unconformity | Unconformity |
| ARCHEAN | ARCHEAN | ARCHEAN |

Lane[1] gives a detailed account of the geology and petrography of Isle Royale, Lake Superior. The island trends north of east and the edges of the strata outcrop in approximately this direction. The rocks are interbedded conglomerates, sandstones, and traps of Keweenawan age, dipping in a southerly direction at angles varying from 8–32°, the higher dips in general to the north. Faults are shown to exist at various places with directions approximately northeast–southwest and northwest–southeast, and the probable existence of other more extensive faults running entirely across the island is indicated. The detailed sections with correlations with the Keweenawan of other parts of Lake Superior are given in table on page 520.

Hubbard[2] discusses the geology of Keweenaw Point with particular reference to the felsites and their associated rocks. The term felsite is used to include all the very fine-grained and highly acid igneous rocks. These occur at a number of horizons below the Bohemian conglomerate, so-called from the fact that it skirts the northern side of this range near the northeastern end of Keweenaw Point. The outcrops of felsite studied occur in Sec. 30, T. 58, R. 27 (New England or Keystone location); Sec. 25 (?), Sec. 35 (Fish Cove), Secs. 26 and 27 (Little Montreal River), all in T. 58, R. 28; Secs. 29 and 30, T. 58, R. 28 (Bare Hill and westward therefrom) Secs. 23 and 24, T. 58, R 29 (Mt. Houghton) and both eastward and westward therefrom; Sec. 10, T. 57, R. 31 (Suffolk location, Praysville); Sec. 4, T. 56, R. 32 (Allouez Gap, east of the Kearsage and Wolverine mines); Sec. 30, T. 56, R. 32 (falls on branch of Trap Rock River); Sec. 36, T. 56, R. 33 (Douglass Houghton Falls), and Sec. 1, T. 55, R. 33 (Hecla and Torch Lake R. R).

The evidence concerning the source of the Keweenawan lavas is considered and it is concluded that they may probably have come from a higher level somewhat back from the edges of the present Keweenawan basin.

With this probability in mind, the following hypotheses are suggested:

1. The irregularities in the lower beds of the Keweenaw series in the Portage Lake area, contrasted with the greater regularity of the

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[1] Geological Report on Isle Royale, Michigan, by A. C. LANE: Geol. Surv. of Mich., Vol. VI, 1898, Pt. 1, pp. 1–281. With geological map.

[2] Keweenaw Point with Particular Reference to the Felsites and their Associated Rocks, by L. L. HUBBARD: Geol. Surv. of Michigan, Vol. VI, 1893–1897, Pt. 2, pp. 184. With plates.

| Name | | Depth in drill hole, feet | Total thickness from 0 feet | Number in Eagle River section | Thickness in Eagle River Section | Copper Falls section | Tamarack section | Conglom-erate numbers | Distances | Minnesota correlations |
|---|---|---|---|---|---|---|---|---|---|---|
| Upper sandstone and conglomerate | | .... | 2600 | 2500 | .... | .... | .... | .... | .... | .... |
| First known trap | Marvine's (c) | 0 | 0 | No. 1 | .... | .... | .... | .... | .... | Temperance River group ? |
| Ophites, numerous sandstones | | .... | .... | .... | .... | .... | .... | .... | .... | |
| Island mine conglomerates | | 170 | 567 | 35 | 1146 | 1035 | 2146 | 18 ? | .... | |
| Transition flows, porphyrite and ophite | | 193 | 589 | | | 1012 | | | | |
| | | 415 | 806 | 44 | 1417 | 745 | 2021 | 17 | .... | |
| Scoriaceous conglomerate | Marvine's (b) | 426 | 817 | | | | | | | |
| Green porphyrites | | 279 | 1100 | 63 | 1810 | 368 | 1639 | 17 | 853 | |
| Scoriaceous conglomerate "Ashbed" | | 291 | 1112 | 65 | .... | .... | .... | | 885 | |
| | | .... | .... | .... | 2035 | 160 | .... | .... | .... | |
| Porphyrites | Marvine's (c) | .... | .... | .... | .... | 0 | .... | .... | .... | |
| Red sandstone | | 377 | 1526 | 80 ? | 2432 | 495 | 1081 | 16 | 1435 | |
| Porphyrites, etc | | 419 | 1567 | | 2496 | 500 | 1053 | | 1445 | |
| Felsite tuff | | 81 | 2035 | .... | .... | .... | 160 | * | .... | Beaver Bay group ? |
| | | 91 | 2045 | .... | .... | .... | .... | .... | .... | |
| Ophite, and the thickest ophite—the Greenstone Conglomerates—the Allouez or "Slide" | | .... | .... | 90 | 2840 | Central mine | .... | .... | .... | |
| | | .... | .... | 108 | 4120 | | .... | .... | .... | |
| | | 363 | 2310 | .... | .... | 0 | 0 | 15 | 2345 | Agate River group ? |
| | | 386 | 2332 | .... | .... | | | | 2378 | |
| Amygdaloids mainly and thin ophites | | 136 | 2570 ? | .... | .... | 660 | .... | 14 | .... | |
| | | 175 | .... | .... | .... | .... | .... | | .... | |
| | | 133 | 3197 | .... | .... | 1474 | 1309 | 13 | .... | |
| | | .... | .... | .... | .... | .... | .... | 12 | .... | |
| breccia | | 386 | 4030 | "Kingston" or Kearsarge ? | | 2599 | 2239 | 11 | 4853 | |
| Minong porphyrite | | 426 | 4068 | | | | | | 4873 | |
| trap | | 456 | 4097 | | | | | | | |
| | | 536 | 4174 | | | | | | | |
| Various beds ending with a thick ophite | | .... | .... | .... | .... | .... | .... | .... | .... | |
| Huginnin porphyrite | | 367<br>436 | 5194<br>5260 | | | | | | | |
| Ophites | | | | | | | | | | |
| Felsitic conglomerate | | 475<br>487 | 5868<br>5879 | | | | | 6 | 7643 | |
| Various igneous flows and conglomerates | | .... | .... | .... | .... | .... | .... | .... | .... | |
| Felsitic conglomerate and felsite tuff | | 786<br>910 | 6155<br>6267 | | | | | | | |
| Felsite | | .... | 6400 | Praysville | | .... | .... | .... | .... | |

* 67.7 above Allouez at Peninsula mine.

higher part of the series, suggest that in this area, near the contact between the Keweenaw series and the Eastern sandstone, we are on the edge of an early-Keweenawan or pre-Keweenawan basin.

2. If the lower beds of the Keweenaw series near Portage Lake rested on the sides of a basin, the later beds of the series from here eastward lay at a higher altitude and, excepting those of the South Trap Range, were eroded in pre-Potsdam time together, possibly, with a part of the underlying Archean.

3. The porphyries found on Keweenaw Point at the contact between the Keweenaw series and the Potsdam sandstone may be in part either,

*a.* Marginal facies of the underlying Archean;

*b.* Intrusive in the early Keweenawan;

*c.* Early interbedded flows of the Keweenaw series; or,

*d.* Remnants of late Keweenawan intrusions by which the eastern margin of the series was broken up and its degradation hastened.

Seaman[1] gives a summary of the geological history of the Keweenawan copper range in Michigan, Wisconsin, and Minnesota. No new point on the geology of the region is added to those already recorded.

Hall[2] describes the pre-Cambrian crystalline rocks of the Minnesota river valley of southwestern Minnesota. These rocks appear in numerous exposures along the river, protruding from the drift, from southeast of New Ulm to Ortonville on the northwest. The great bulk of the crystalline rocks are granites and gneisses. These appear for the most part in the river bottoms, but stand also in a few isolated knobs on the higher ground south and west of the river. There are many varieties of granites and gneisses and all gradations between them. They are taken as a whole to represent the Archean or Basement complex.

Associated with the granites and gneisses are a much smaller number of exposures of gabbros and gabbro-schists. These present many varieties, all of which are believed to have resulted from the alteration of two original forms and their intergradations — a hypersthene-bearing gabbro and a hypersthene-free gabbro.

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[1] Geology of the Mineral Range, by A. E. SEAMAN: First Ann. Rept. of the Copper Mining Industry of Lake Superior, 1899, pp. 49–60.

[2] The Gneisses, Gabbro-Schists and Associated Rocks of Southwestern Minnesota, by C. W. HALL: Bull. U. S. Geol. Surv., No. 157, 1899, pp. 131. With geological maps.

Peridotite is found in one exposure only in this valley, three miles southeast of Morton. The relations to the other rocks of the area could not be determined. Cutting the gneisses and gabbro-schists throughout the area are numerous dikes of diabase. They vary in width from a fraction of an inch to 175 feet. Their age is probably Keweenawan.

Southeast of Redstone and near New Ulm are exposures of quartzite associated with coarse quartzite conglomerate. Near Redstone the strike of the quartzites is N. 60–70° W., and their dip varies from 5–27° N. In New Ulm the strike is N. 15° E., and the dip varies from 10–15° S. E. The quartzite is believed to be the same as the quartzite found in a deep well at Minneopa Falls, near Mankato, Minn., which is covered by a quartzite conglomerate of Middle Cambrian age. The quartzite of Redstone and New Ulm is above the Archean granite and gneiss. It is believed to be of Huronian age, but whether Upper or Lower is unknown.

Overlying the crystalline rocks are Cretaceous shales and sandstones, which appear in rare exposures in the valley, and glacial drift.

Coleman[1] discusses areas mapped by Logan as Huronian north of Lake Huron and the east end of Lake Superior. The two contacts described by Irving and Van Hise as contacts of the Lower Huronian and Laurentian rocks were examined. At the first, on the islands four miles east of Thessalon, jasper and chert fragments were found in the conglomerate above the Laurentian, indicating that the conglomerate is probably a part of an upper series, younger than a series of rocks, not Laurentian, from which the jasper must have been derived. At the other contact, on the road between Sault Ste. Marie and Garden River, it is concluded that the conglomerate is possibly a crushed conglomerate formed by faulting instead of a water-formed rock.

Certain green and gray schists inclosed in the Laurentian gneisses are believed to represent the western Keewatin of Lawson.

The Laurentian and Huronian contact at Goulais and Batchawana bays was found to be in general of the nature of an eruptive contact, although a clear example of the inclusion of a typical Huronian rock in the Laurentian was not observed.

The slate-conglomerate of Doré River contains no bowlders that are distictly Laurentian. It contains only fragments of schists and eruptives from rocks which have been called Huronian. It probably has closer affinities to Lawson's Keewatin than to Logan's Original Huronian.

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[1] Copper Regions of the Upper Lakes, by A. P. COLEMAN: Rept. of the Bureau of Mines, Ontario, Vol. VIII, Pt. 2, 1899, pp. 121–174.

On the shores of Heron Bay the schist-conglomerate and slate were examined. The conglomerate contains fragments mainly of granite. These rocks are more closely allied to the Keewatin than to the Original Huronian type.

In general it is believed that Logan mapped as Huronian, rocks which are really Huronian and Keewatin.

The ascending succession for the region as indicated by the above facts is as follows: Keewatin, consisting mainly of basic green-schists; Laurentian, consisting mainly of moderately acid eruptives; and Huronian. The term Laurentian is confined to areas of granite and granitoid gneiss corresponding to the Ottawa Gneiss of eastern Canada, and having eruptive relations to the Keewatin.

The Keweenawan rocks of the various area on the north shore of Lake Superior were studied, but no important conclusions were reached differing from those of Irving. One variety of conglomerate, made up chiefly of underlying Laurentian rocks is common on the north shore, which apparently has not been found on the south shore.

*Comments.*—This discussion points toward the conclusion that the Original Huronian rocks of Logan are largely a series above and later than certain rocks to the west mapped by Logan as Huronian, and other rocks still farther to the west mapped by Lawson as Keewatin; further that the Laurentian rocks intrude the earlier series, and are unconformably overlain by the later Original Huronian series of Logan.

That the Original Huronian, in large part, is younger than some of the Keewatin rocks of Lawson is possible. The finding of chert and jasper fragments in the conglomerate cited by Irving and Van Hise as Lower Huronian would show that more of the series belongs to an upper division than was supposed.

However, as Dr. Coleman himself would fully agree, there still remains evidence to indicate that rocks of both Upper and Lower Huronian series are present in the Original Huronian area, and for the Keewatin of Lawson the evidence is conclusive that two or more series are represented. In view of this wide range of rocks in both areas, and the wide separation of the areas it is unsafe at present to make a definite statement concerning the relative ages of Lawson's Keewatin and Logan's Original Huronian, based on lithological character and relations to the intrusives.

Dr. Coleman's conception of the Laurentian is the same as that attributed to the Canadian geologists in general in the comments on p. 440.

McInnes[1] describes the geology of the Seine River and Lake Shebandowan map-sheets, which cover an area extending west and northwest of Port Arthur, Ontario. Laurentian granites and gneisses with many variations occupy three fourths of the area. The relations to the overlying Keewatin and Coutchiching rocks, wherever they have been found in contact, have been those of intrusion.

The Huronian is represented by Coutchiching and Keewatin rocks.

Coutchiching mica-schists and fine-grained gneisses, a continuation of Lawson's Coutchiching in the Rainy River district to the west, enter the area of the Seine River sheet on the west side. However, toward the east these rocks become associated with large quantities of gneisses, and for the eastern two thirds of the Seine River sheet and for the entire Lake Shebandowan sheet the gneisses are predominant and the belt is mapped as Laurentian. In other parts of the district the Keewatin schists, near their contact with the Laurentian gneisses, assume a character exactly similar to the Coutchiching schists and associated gneisses, and could not be lithologically distinguished. Indeed, the Coutchiching seems to be an extremely altered phase of the Keewatin.

In long bands infolded with the Laurentian and conforming in strike with the foliation of the gneiss are bands of Keewatin rocks varying greatly in width. They vary in composition from extremely basic igneous masses, and their derived products, to acid quartz-porphyries, and their derived products, and include also quartzites, conglomerates, and slates. The basic rocks form the largest volume of the rocks of the series. The series is separated lithologically in mapping into three divisions. There can be no doubt that the Keewatin here includes rocks which are of widely differing age.

Overlying unconformably the Keewatin rocks is the Steep Rock Lake series, so named from its occurrence in the neighborhood of this lake. The series is mapped as an upper division of the Keewatin series. As described by Smyth it comprises conglomerate, limestone, clay-slate, and various basic volcanic and intrusive rocks. Because of the folding of the series it is believed to be older than the Animikie strata of Thunder bay.

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[1] "The Geology of the Area Covered by the Seine River and Lake Shebandowan Map-Sheets, comprising Portions of Rainy River and Thunder Bay Districts, Ontario," by WM. McINNES: Ann. Rept. Geol. Surv. of Canada, Vol. X, Pt. H, 1899, pp. 13–51. With geological map.

Animikie rocks occur in a small area in the southeast corner of the Shebandowan sheet. They overlie unconformably the Keewatin and Laurentian rocks, and from their stratigraphical relations to the overlying formation farther east on Lake Superior they are believed to be of Lower Cambridge age.

*Comments.*—The mapping of this area of these sheets has been largely lithological, the red granites and gneisses and their associated rocks of various ages being mapped as Laurentian, and the green rocks and the associated sedimentaries being mapped as Huronian. However, a distinct advance is made in seeing that some of the Coutchiching rocks are no more than metamorphosed Huronian or Keewatin rocks. This is a frank awowal that the Coutchiching series is a lithological, not a structural unit.

The Steep Rock Lake conglomerate was considered by Smyth and Pumpelly as the basal portion of the Lower Huronian, and the underlying rocks as Archean. McInnes has mapped the underlying rocks as Keewatin, and has included in them sedimentary and igneous rocks. He has not separated from them sedimentary rocks which may be the equivalent of the Steep Rock series.

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